Interim Progress Report submitted to NOAA's Human Dimensions of Global Change Research (HDGCR) Program

Project Title: "Use of Climate-Information Products by Water Managers and Other Stakeholders in Two GCIP/GAPP Watersheds in Arizona/Sonora and Oklahoma"

Investigators:

Robert Varady, Udall Center for Studies in Public Policy, University of Arizona. rvarady@u.arizona.edu

Anne Browning-Aiken, Udall Center, browning@u.arizona.edu, 520 884-4393

Robert Merideth, Udall Center, merideth@u.arizona.edu

Barbara Morehouse, Institute for the Study of Planet Earth, University of Arizona, morehoub@u.arizona.edu. 520 622-9018

David Goodrich, ARS Southwest Watershed Research Center, dgoodrich@uswcl.ars.ag.gov, 602 437-1702

Jean Steiner, ARS, Grazing Lands Laboratory, El Reno, Oklahoma, jsteiner@grl.ars.usda.gov, 404 262-5291

Margaret Wilder, Center for Latin American Studies, University of Arizona. mwilder@u.arizona.edu, 520 626-7231

Melanie Lenart, Institute for the Study of Planet Earth, University of Arizona, mlenart@u.arizona.edu, 520 882-0879

NOAA Grant Number
Time period covered: August 2003-July 2006

I. Preliminary Materials

A. Project Abstract

Building upon previous research and outreach efforts in the San Pedro Basin (Ariz./Sonora) and Washita/Red-Arkansas Basin (Okla.), we propose a three-year project to continue and expand our efforts to 1) assess climate information products/tools for water management, 2)find ways to narrow the communication gap between climate experts and information users, and 3) improve ways to integrate the science of climate with public policy. The two basins have been designated, with the support of the NOAA/GEWEX Water Resource Applications Project (WRAP) as Reference Basins by the emergent UNESCO-based, global HELP (Hydrology for the Environment, Life and Policy) Initiative. This work is intended to expand the body of research related to the theoretical and practical aspects of the role of climate information for water management, stakeholder decisionmaking, and public policy, and build upon the contributions from regional climate impacts and vulnerability assessments, particularly those focused on water basins.

B. Objective of Research Project

Assess products and tools

- Assess status of available climate information useful in a transboundary context
- Obtain evaluation of transboundary climate information from stakeholders
- Determine product usability, accuracy, and utility in interaction with natural resource/water stakeholders/managers
- Identify potential opportunities to transfer NAME products into transboundary settings

Bridge communications gap

- Narrow knowledge and communications gaps between climate researchers/products and area stakeholders
- Identify areas where improvements in climate products could be made and provide feedback to climate scientists/forecasters.

Integrate science and policy

- Assess the potential impacts of climate variability and change on water policy, economic development, and land management/land use practices.
- Identify promising avenues for introducing science into policymaking
- Identify innovative ways to link stakeholders with forecasters in regards to the on-going work by the USDA/ARS in the Red-Arkansas Basin with forecast models for the interface between land use, climate and hydrology
- Assess the potentials and constraints of using the watershed council framework and water focus groups for integrating science and policy

C. Approach

Assess products and tools

- Using archival information and surveys, analyze trends in demographics, institutional changes, water management, economic growth, and land use/land tenure arrangements.
- Using focus group and workshop techniques, assess need for/use of climate information
- Introduce stakeholders to climate forecasts and related information through structured workshop settings; use structured workshop interactions, as well as follow-up surveys, as needed, to obtain feedback on utility, usability, and perceived accuracy of the information provided
- Conduct structured analysis of results of focus groups, workshops, and surveys to assess climate perceptions and how these are linked with decisions/actions
- Using the DSS model developed by Kevin Lansey, develop an assessment of the sensitivity of water resources on Mexican side of border to climate variability (assuming sufficient data are available to conduct the analysis). Using the results of surveys and focus groups, assess the capacity of basin residents to design and implement adaptive management strategies that reduce/avert vulnerability to climatic stresses

Bridge communications gap

- Conduct preliminary focus groups to ascertain how participants define and view climate, identify the types of climate conditions that pose the greatest concern, as well as the greatest potential benefit to area residents and to identify current coping mechanisms.
- Hold capacity-building workshops in the use and interpretation of climate information with watershed councils or climate and resource focus groups
- Link local southwestern Oklahoma land and water agencies with the ARS Grazing Lands Research Lab and Oklahoma University's Mesonet

- Establish a regional coordinator/facilitator in southwestern Oklahoma to promote the collaboration of federal and state water agencies, tribes and local landowners on regional water, climate, and land use issues

Integrate science and policy

- Investigate land tenure, soil and water management in Mexican portion of the San Pedro for policy implications under conditions of climate variability and change
- Carry out a structured assessment of the results of the research conducted in this project to determine extent to which science is already integrated into policy structures and the potential for/barriers to introduction of climate information into such processes.
- Identify changes that must be made in organizational, institutional, and professional frameworks in order to increase the integration of science into policy making and implementation processes, including enhanced participation of community members in scientific research as well as increased outreach from scientists to residents of the region

D. Description of any matching funds used for this project

The effort comes on the heels of a successful project with compatible aims, funded by the Dialogue on Water and Climate for approximately $70,000. That project ended just when the present grant began. In addition, the Udall Center receives an average of about $40,000 per year of support from the NSF-funded SAHRA program administered by the University of Arizona. Finally, as the foregoing text makes clear, this work is closely linked to the ongoing CLIMAS project managed by the University of Arizona's Institute for the Study of Planet Earth, with which it shares two co-investigators.

II. Interactions

A. Decisionmakers

Via the list of meetings presented below, organized principally by Co-PI Anne Browning-Aiken, we interacted with numerous decisionmakers in the basin, including the mayor of Cananea, Sonora; the city planner of Cananea; members of the Sonora-Arizona Regional Environmental Association (ARASA); Sonoran water officials with the state agency, COAPAES, Hermosillo; officials from the Mexican National Water Commission (CAN) in charge of watershed council planning, Hermosillo; representatives of other Sonoran nongovernmental organizations (e.g., *Red Fronteriza)*; as well as individual members of watershed councils in the state of Sonora:

- July-Sept 2003 San Pedro Dialogue on Water and Climate Mexican basin survey of climate and hydrologic information use by basin water managers, basin rural and urban residents (including changes in water use due to climate variability)
- Nov. 6, 2003 San Pedro Dialogue on Water and Climate meeting in Cananea with a goal of initiating a binational water alliance between the Upper San Pedro Partnership and a Mexican water committee
- Jan. 2004 University of Arizona Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA) presentation of decision-support model, "Evaluation of Conservation Measures in the Upper San Pedro Basin" by Kevin Lansey and Derya Yalcin. This DSS model can be expanded to the Mexican portion of the basin with data and technological support from DICTUS and climate variability can be programmed in the model
- Jan.-March 2004 attempt to enlist support of IMTA, coordinator of Water Technology Javier Aparicio, in support of the new San Pedro Binational Alliance

- Feb 26-27, 2004 meetings with University of Sonora Department of Scientific Investigations (DICTUS) to extend basin collaboration on water and climate research
- Feb. 27, 2004 meeting with Mexican National Water Commission, Sonoran State Water Commission, and EPA Border 2012 to solicit support for the establishment of a San Pedro basin water committee
- March-May 2004 series of meetings with COAPAES and mayor, city planner of Cananea to discuss municipal water assessment report, CNA and formation of municipal water committee, and the development of a short and long-range development plan for Cananea
- May 11, 2004 San Pedro Binational Alliance Technological Meeting with University of Sonora (DICTUS), Arizona State University, SAHRA, USGS, Upper San Pedro Partnership to discuss the potential for data-sharing and assessment for the binational basin and the establishment of a binational virtual San Pedro Research Institute, including components of climate research
- May 21, 2004 EPA/CNA Border 2012 meeting in the San Pedro to discuss support for proposed projects of Binational San Pedro Alliance. (Support was not forthcoming). Discussion of climate, especially drought concerns, particularly the Arizona Drought Task Force's Drought Vulnerability Plan. When asked about their plans for drought in terms of basin management, CNA did not have any. Their current concerns are with the Costa de Hermosillo and the city of Hermosillo, with the potential for a desalinization plant to address water shortage concerns. CNA, like the Alliance Tech Committee, Arizona Dept. of Environmental Quality (ADEQ), and Good Neighbor Environmental Board (GNEB), is planning a border wide data assessment. CNA is seeking information from Sonoran universities as well as its own offices.
- Co-PI David Goodrich has been meeting regularly (~2 days per month with the Upper San Pedro Partnership (USPP - http://www.usppartnership.com/) to develop a report to Congress by December 31, 2004 as required by Section 321 of the FY 2004 Congressional Defense Spending Bill. This plan calls for eliminating deficit pumping of the Sierra Vista subwatershed of the San Pedro by 2011. This has involved meetings in the Technical, Public Advisory, Administrative, and Staff Working Group committees of the USPP.

B. Climate forecasting community

- Co-PI David Goodrich has been coordinating with Dr. Tom Jackson (ARS, Beltsville) in planning the SMEX'04 field campaign which will take place over the San Pedro and near Hermosillo, Sonora (http://hydrolab.arsusda.gov/smex04/). This campaign is a key terrestrial component of the larger NAME (North American Monsoon Experiment, http://www.joss.ucar.edu/name/). NAME is an internationally coordinated, joint CLIVAR-GEWEX process study aimed at determining the sources and limits of predictability of warm season precipitation over North America, with emphasis on time scales ranging from seasonal-to-interannual.
- National Water Commission officials, climate forecasting, Hermosillo Office. Although the structure of management may be decentralized, the structure of information flow is highly centralized within the CNA. Also, the access to climate information is uneven, as is the ability to use and interpret adequately and appropriately.

C. Coordination with other projects of the NOAA Climate and Societal Interactions Division

• Coordination with Climate Assessment of the Southwest (CLIMAS) project, Institute for the Study of Planet Earth, University of Arizona

III. Accomplishments

Climate Workshop in Hermosillo April 26-27, 2004

From the perspective of the Udall Center and the Institute for the Study of Planet Earth (ISPE), the purpose of the meeting was two-fold:

1) to explore the idea of a regional climate center, perhaps based in Hermosillo, a discussion initiated among Mexican and U.S. climatologists at a meeting in La Paz the previous year; and
2) to meet with Mexican climatologists to determine their interest in participating or otherwise contributing to San Pedro Basin climate workshop(s), which the Udall Center and ISPE plan to hold as part of a NOAA grant. The workshop(s) is/are expected to help specific stakeholders, such as water managers, city planners, and ranchers or *ejiditarios*, understand climate better so they can consider climate variability in their decision-making.

Co-PI Melanie Lenart gave a PowerPoint presentation explaining the functions of CLIMAS, a NOAA-funded project administered through the University of Arizona's Institute for the Study of Planet Earth. There was interest in how CLIMAS adds value to climate information in its products and publications and its work with stakeholders. CLIMAS' initiative on providing a seasonal wildfire forecast for the Southwest attracted particular interest, and participants were disappointed that the forecast does not cross the U.S. border with Mexico. (Martin Ortiz and some others expressed an interest in perhaps becoming involved in future wildfire forecasts.) Similarly, the monsoon was identified as a phenomenon that should be studied on both sides of the border. Tereza Cavazos and Henry Diaz are involved in the North American Monsoon Experiment (NAME) being carried out in Mexico this summer.

The general sentiment seemed to be that CLIMAS would be a good role model down the road, but that infrastructure for a regional climate center would need to be in place before the group meeting in Hermosillo would be ready to move forward on working with stakeholders. An attempt to discover interest from a potential stakeholder, the CNA, faltered when its representatives indicated they did not know what they needed. (A subtext seemed to be that they feared if they identified a need, they would be asked to fund it.)

Collecting and organizing data would be one of the first steps to be undertaken by the center, participants agreed. Benjamin Valdes of INIFAP suggested that perhaps CLIMAS and SAHRA could indicate their support for a regional climate center with a letter of cooperation. Melanie concurred. In Sonora, there are:

- 145 stations, of which 40 to 50 report daily data by radio and other media.
- 16 hydrological stations, although not all of them are working
- Large-scale data annually

Julio Cesar of IMADES advocated a Sonoran-wide climate monitoring system. He noted that there's a big difference in climate between northern and southern Sonora. The region needs: real-time data that is accurate; warning for extreme events; and resource protection, he said. The Hermosillo station has data for wind velocity, he noted, and he showed a correlation between changes in wind direction and a drop in humidity. Right now volunteers collect weather data in the region. A system is in place, which uses data transferred by satellite from automatic weather stations, and is used by farmers, ranchers, the government, non-governmental organizations, the

public and students, among other stakeholders. He discussed setting up a larger system (with each station costing about $12,000). It would cost about $1 million to set up 70 stations, and then about $140,000 a year to maintain them.

Jose Grageda Grageda of INIFAP gave a presentation on the state network to modernize Sonoran agricultural climate products, such as frost reports. Grapes, wheat and various fruits are grown in this region. CNA is a source of information, but the infrastructure is inadequate and difficult to access. He suggested a system that would cost $6.6 million pesos a year (about half a million dollars) to produce this information.

Jaime Garatuza of ITSON suggested that the networking aspirations should be considered separately from the regional climate center idea.

A couple of representatives from the agricultural sector indicated ranchers needed climate forecasts about a month in advance, whereas farmers needed perhaps six months warning of a dry season so they could find other work. Henry explained that a six-month categorical forecast would not be feasible, and that the probabilistic approach to forecasts would be more likely. The regional center could be a conduit for making such forecast useful to the user.

Co-PI Melanie Lenart was asked to consider how CLIMAS might be willing to be involved in the regional climate center. Also, Teresa Cavazos of CICESE in Ensenada, suggested that she ask CLIMAS-affiliated postdoctoral researcher Marcela Vazquez-Leon about her interest in working with the center because of her background researching agricultural vulnerability in northern Mexico.

Sonoran Climate Variability Study

The study has produced a concrete vision, mission and goals, as well as a time line and tangible strategies to be followed in this study. Data research and collection in a variety of Mexican, U.S. and international sources, as well as participation in U.S.-and Mexico- based Climate workshops / forums. The study is also monitoring and assessing different sources of climate information. For this purpose, alliances with U.S. (NOAA) and Mexican Climate experts (CICESE, DICTUS, UNAM) have been forged to provide a comprehensive and integrated data collection and interpretation. Data collection focuses on climate variables (precipitation, temperature, stream flow, soil humidity) from southern Arizona and northern Sonora, that will facilitate the assessment of climate variability in the Sonoran desert biome and in particular in the transitional area of the Upper San Pedro River Basin.

Climate, Water Management, and Policy in the San Pedro Basin: Results of a Survey of Mexican Stakeholders Near the U.S.-Mexico Border

Under the auspices of the Dialogue on Water and Climate and NOAA, water and climate surveys assess the quality and usability of climate and hydrologic information available to water managers and communities in the Mexican portion of the San Pedro River Basin. The surveys indicate that the central concern for urban residents is the lack of reliable potable-water due to frequent service breakdowns—with climate change and variability, specifically drought and high temperatures, as contributing factors. Water managers desire appropriate meteorological and hydrologic information to improve planning strategies, but access to this information remains limited. Considerable disagreement exists about who should pay for previously free or low-cost water and wastewater treatment. Urban users have little incentive to conserve because of the flat low rate and frustration with service. In rural areas, while a majority of ranchers recognize that variable climate and water loss jeopardizes their lifestyle, they seldom use meteorological information in planning or modify their water consumption. Climate vulnerability also

includes potential for serious environmental health issues due to the presence of heavy metals and organic contaminants in the San Pedro.

Establishment of a Binational San Pedro Alliance Technological Committee to work on hydrology and climate data exchange and coordination

A. Brief discussion of research tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken.

- The 2004 Working Conservation Plan of the Upper San Pedro Partnership (http://www.usppartnership.com/documents/2004.plan.pdf) was published in Feb. 2004 with contributions from Dr. Browning-Aiken and Dr. Goodrich. A draft of the Congressionally requested 321 report and plan will be presented to the USPP Public Advisory Commission by the end of June 2004

- Completion of a socioeconomic and demographic database for the binational San Pedro area, including Cananea, Naco municipios (in Sonora) and Cochise County (in Arizona)

- Three climate and water surveys were constructed by a US and Mexican team of anthropologists, geographers, and an arid-lands specialist to obtain a clear picture of water and climate information and technology needs of the Mexican portion of the basin**.** A team of Mexican interviewers trained by the Udall Center administered 507 water and climate surveys in the Mexican portion of the Upper San Pedro River Basin. For the municipal domestic water users survey, the city of Cananea, Sonora, was divided into eleven sections according to population density based on population statistics from the Mexican Instituto Nacional de Estadistica Geografía e Informática (INEGI). From these sections 400 respondents were randomly selected from a hat on a percentage basis according to population density. For the water manager survey, three water managers were interviewed from COAPAES and OOMPAS in both Cananea and Naco and one from the regional Comisión Nacional del Agua. Three managers of bottled water companies in Cananea were also interviewed. For the rural water users, 160 surveys were taken in four ejidos located along the Mexican portion of the San Pedro River: Emiliano Zapata, Ignacio Zaragoza, José Maria Morelos, and Cuauhtemoc.

  Face-to-face survey interviews (560) were conducted in Cananea by a Mexican team during a time of water crisis when service breakdowns had been frequent. . In addition, summer heat and periodic drought had increased the demand for water in the basin as a whole. There was a strong interest in the surveys and a sense of frustration among water users in regards to their experiences with a safe and steady supply of water.

  The interview protocol was divided into five sections: personal data, water service and use over the last five years, impacts of climate change and variability on water use, access and use of information on climate and aquifer conditions, evaluation of the seriousness of community water problems and responsibility for water management, and how water costs should be paid. Rural surveys also looked at the relationship between crop and cattle selection and water use. A separate water manager protocol also included five sections covering work background, the impacts of climate change and variability on water management strategies, access to climate and hydrologic information, community access to climate information, water supply, distribution, and infrastructure, and policy issues.

  Researchers created a cross-cutting index to represent “perceived water system vulnerability.” The index incorporated thirty-six variables (all ordinal data) grouped as follows: eighteen questions on perceptions grouped as follows: eighteen questions assess perceptions of climate vulnerability and impact, including ten questions on the perception of frequency of different extreme climatic events over the past ten years, and eight questions on the perception of frequency of domestic water service difficulties directly tied to climatic conditions over the past ten years. Two questions gauged perceptions of water quality, while sixteen questions asked respondents to rate the seriousness of community-wide water issues. All 36 questions produced ordinal data on a scale of one to five, with five representing the worst

situation (perceived frequency of climatic shocks, worst water quality ranking, most serious community water problems), and one representing the best scenario or least perceived impact. The 36 variables provide an index with reliability coefficient of alpha .7515, indicating that each variable is sufficiently correlated to the overall index for inclusion. Each individual respondent was assigned a score for the index representing the sum of the 36 variables.

As an interpretive tool by which to understand the perceptions of rural and urban water users surveyed, the index is not an objective attempt to quantify or qualify actual water system vulnerability. To do so is beyond the scope of this study (see Gleick et al. 2002, Sullivan et al. 2003, and Finan et al. 2002 for discussion). Nor is the index meant to demonstrate that our test area is more of a "hot spot" than surrounding areas. As a measure of perceptions, the score does two things: it permits researchers to compare a composite of several responses from a single respondent to independent variables such as age, gender, and geographic location, and secondly, the range and distribution of household perceptions provides a picture of variability across the population with respect to water system vulnerability.

B. Summary of any preliminary findings

Many of the findings and results of the Mexican San Pedro Water and Climate Survey point strongly toward vulnerability associated with lack of basic water infrastructure, water quality concerns, and institutional issues than they do toward climatic vulnerability. However, given the high baseline level of water vulnerability, climatic variability and change have the potential to intensify the effects of already-existing problems. The observations below provide insight into the multiplicity of challenges faced by Mexican stakeholders in the Upper San Pedro River Basin, and into how climate information might be successfully integrated into decision making at scales ranging from households to the entire upper basin.

Observation #1 Water managers' and water users' access to resources, specifically finances and technology, and local management capacity play a critical role in determining water system vulnerability.
Observation # 2: Urban and rural water users recognize that water service problems, particularly those associated with water quality, can impact regional health, but, not surprisingly, tend to associate these problems with water management rather than climate variability.
Observation #3 Water users do not believe that lack of access to reliable information about climate and aquifer conditions contributes to the vulnerability of their water system or to access to reliable potable water service.
Observation #4 Urban and rural water users do not currently modify their water consumption in response to climate variability or change.
Observation #5 Water managers do modify their management strategies in response to climate variability or weather stresses.
Observation #6 Few urban or rural households have water storage capacity to meet their water demands under drought conditions.

C. Papers and presentations arising from this project

• Browning-Aiken, Anne and Denise Moreno, 2nd International Forum, Gestion Social de Cuencas Hidrograficas presentation. May 13-14, 2004, "Building Alliances: The San Pedro River Basin"

• Browning-Aiken, Anne Barbara Morehouse, Allison Davis, Margaret Wilder, Robert Varady, Robert Merideth, David Goodrich, Rebecca Carter, Denise Moreno, Emily Dellinger, Francisco Delgado, Arturo Rodriguez, Felix Villaseñor, Mireya Cons 2003. Climate, Water Management,

and Policy in the San Pedro Basin: Results of a Survey of Mexican Stakeholders Near the U.S.-Mexico Border. Submitted to *Climate Change.*

• Browning-Aiken, Anne, Holly Richter, David Goodrich, Bob Strain, and Robert Varady. 2003. The Upper San Pedro Basin: Fostering Collaborative Binational Watershed Management. 2003. To appear in *International Journal of Water Resources Development.*

• Browning-Aiken, Anne, Robert Varady and Denise Moreno, 2003. "Binational Coalition-Building: A Case Study of Water Resources Management in the Upper San Pedro Basin of Sonora-Arizona," *Journal of the Southwest* 45(4):611-632.

• Goodrich, David C., Plenary presentation entitled "The Dance Between Science, Decision Making, and Public Education for Natural Resource Management" to the Connecting Mountain Islands and Desert Seas Conference, May 11-15, Tucson, AZ.

• Varady, R. G., A. Browning-Aiken, D. Goodrich, W. J. Shuttleworth, R. Strain, H. Richter, A. L. Ross, and D. Moreno. In press. The Upper San Pedro River HELP basin: an informal, binational approach to watershed management. In *The Role of Hydrological Information in Water Law and Policy: Current Practice and Future Potential*, ed. by J. S. Wallace, P. Wouters, and S. Pazvakavamba. Dordrecht, The Netherlands: Kluwer Academic Publishers.

• Varady, Robert G. and Anne Browning-Aiken, In press. "The Birth of a Mexican Watershed Council in the San Pedro Basin ion Sonora," in *Planeación y Cooperación Transfronteriza en la Frontera México-Estados Unidos (Transboundary Planning and Cooperation in the U.S.-Mexico Border Region)*, ed. C. Fuentes and S. Peña. Mexico City.

• Varady, R. G., and B. J. Morehouse. In press. *Cuanto cuesta*? Development and water in Ambos Nogales and the Upper San Pedro Basin. In *The Social Costs of Industrial Growth in Northern Mexico..*, ed. by K. Kopinak. La Jolla, CA: Center for US-Mexican Studies, UCSD.

• Wilder, Margaret. "Transformation of the Mexican Water Sector: Decentralization and Evolving Water Institutions," Conference of Latin Americanist Geographers (CLAG), 2004 Annual Meeting, May 19-21, 2004, Antigua, Guatemala.

• Wilder, Margaret and Katie Meehan. May 6, 2004 "Integrating Climate Planning in Mexican Water Institutions," CNA office, Hermosillo, Sonora.

D. Significant deviations from proposed work plan

One of the challenges of the San Pedro aspect of the project involves the difficulty in accessing information on climate variability in real time. There is no web-based data storage system to which a user can turn for information on how local temperature and precipitation compare to previous years, for instance. In most places, climate monitoring did not begin until the 1960s, and data collection was not always consistent. Some records begin in the mid-1980s, and there are many gaps in climate records. The CNA reportedly has some of this data, but charges a fee for its use. The availability of information is such that collecting and organizing data was identified as a necessary first step of a proposed regional climate center by the dozen or so climatologists from Mexico or with expertise on Mexico who attended the April 26-27 meeting in Hermosillo. The regional climate center is proposed for establishment at the University of Sonora in Hermosillo, Mexico. Participants in the planning workshop who attended a presentation by

CLIMAS postdoctoral researcher Melanie Lenart responded with the general sentiment that producing value-added climate products for stakeholders was probably beyond the scope of the proposed regional climate center in its early stages. Given that this is seen as a challenge by Mexican climatologists, it seems unlikely that a U.S.-based project will be able to develop such stakeholder tools, as had been initially proposed in this grant.

However, it does seem possible to use workshops to provide stakeholders with a basic background on the climatic influences that affect the San Pedro watershed, such as the monsoon and the El Niño Southern Oscillation (ENSO). The Nature Conservancy is planning to hold a workshop in Spanish for Sonoran ranchers on the Mexican side of the border, and TNC organizer Peter Warren has been supportive of a suggestion that someone from this grant give a presentation on climate variability in the region as part of the one-day workshop scheduled for September. In addition, the North American Monsoon Experiment (NAME) provides some opportunity for stakeholder education that could be facilitated by recipients of this grant. Further, some of the Mexican climatologists who attended the Hermosillo meeting indicated they would be interested in collaborating in the National Seasonal Assessment Workshops, led partly by CLIMAS, to identify potential western fire risk for the upcoming season based in part on climate forecasts. Participants in this grant may be able to serve as a bridge to facilitate the future involvement of Mexican stakeholders in the NSAW initiative.

In the meantime, the grant is providing funding for a graduate student researcher to collect data on climate variability as it applies to this region. Information is being compiled about what data is available and what peer-reviewed and other papers are relevant for potential stakeholder workshops. It is hoped that the data will be compiled into a Spanish-language information booklet that can eventually be distributed to interested stakeholders in the region. Also, co-PI Tereza Cavazos has compiled a list of web-based weather and climate information, many of them produced by U.S.-based agencies, that she makes available from her web page at the following address: http://oceanografia.cicese.mx/~tcavazos/weather.html . Some of these links could be provided to stakeholders as relevant to their concerns.

When Morehouse and Browning-Aiken met with the Upper San Pedro Partnership about becoming participants in an assessment of climate information tools in basin water management in the US portion, the Partnership stated it had sufficient access to climate information tools through its connection with the army base at Ft. Huachucha. However, as indicated above, climate data can be inserted into the DSS model by Lansey and Yalcin.

The greater challenge has been to get CNA to cooperate with researchers and basin water managers in supporting the establishment of a Mexican water committee in the basin. Due to higher priority concerns elsewhere in the state, CNA says it will provide support by the end of this year.

IV. Relevance to the field of human-environment interactions

A. Describe how the results of your project are furthering the field of understanding and analyzing the use of climate information in decisionmaking

While the USPP is developing a water budget for average conditions, with recharge and ET figures derived from a calibrated groundwater model, they realize that components of the water budgets will vary from year to year and more detailed accounting must be undertaken to meet the planning requirements under Section 321 Federal Legislation.

We are finding that collaboration with local water managers in Mexico is challenged by the slow pace of decentralization, wherein management authority remains at the federal agency level with little power devolved to the municipal or subbasin level. Thus basin water managers are limited in their participation in a binational basin alliance to address water and climate concerns. Climate information is centralized within the national water agency (C.N.A.) but use of climate science has not yet been well-integrated into decentralized water institutions. The newly-evolving watershed councils (consejos de cuenca) offer a potential opportunity for enhanced utilization of climate science to effect more sustainable environmentally-sound planning at the basin level, but the watershed councils are limited by having little formal authority. The short (3-year) administrative terms of municipal and state water managers (who tend to change with each new political administration at the "mayoral" or gubernatorial level) also creates challenges for sustained collaborations over longer time horizons.

B. Where appropriate, describe how this research builds on any previously funded HDGEC research

• NSF funded research of SAHRA: Kevin Lansey's decision-support system of the San Pedro Basin

• Coordination with Reg. Integrated Sciences: Integration with the Climate Assessment of the Southwest (CLIMAS) project, University of Arizona, Margaret Wilder, PI. Project: Decentralization and Urban Water Institutions in Sonora, Mexico

• Current research builds on the capacity-building of a basin NGO the Sonora-Arizona Regional Environmental Association, which has an active role in promoting a binational alliance. An EPA environmental education grant (ECOSTART II) continues water and climate education in basin schools.

C. How is your project explicitly contributing to the following areas of study?

1. Adaptation to long-term climate change: climate and water survey has identified need for climate information and adaptation strategies

2. Natural hazards mitigation

3. Institutional dimensions of global change: meetings with CNA, COAPAES water managers regarding climate data

4. Economic value of climate forecasts

5. Developing tools for decision makers and end-users: Kevin Lansey's DSS model of the San Pedro Basin

6. Sustainability of vulnerable areas and/or people: The Mexican climate and water survey has established a vulnerability index for the upper part of the basin. The survey calls into question current management practices regarding adaptation to prolonged drought conditions.

7. Matching new scientific information with local/indigenous knowledge: The Mexican climate and water survey asked basin residents (rural and urban) about their experiences with climate variability and its impacts on their access to potable water.

8. The role of public policy in the use of climate information: The study of Mexican water policy is ongoing because of the current trend toward decentralization of natural resource management to state and municipal levels. However, the process is slow and decision-making for the basin remains in the hands of the regional CNA director.

9. Socioeconomic impacts of decadal climate variability

10. Other (e.g., gender issues, ways of communicating uncertain information

TABLE 1. TIMELINE FOR PROPOSED WORK IN SAN PEDRO AND WASHITA BASINS
*(principal investigators noted in **boldface**)*

Research Areas	Scientific Objectives	Methodology	YR 1	YR 2	Y I 3
1. Assess products and tools	1.1) Identify trends in demographic and economic growth and stresses on regional stakeholder livelihoods and link those stresses to stakeholder climate information needs and determine the potential impacts of climatic variability on various sectors in the basins and evaluate the sensitivity of water resources supply and demands to climatic variability (both basins). ***Morehouse,*** *and Carter, Conde, Rodríguez, Sorrensen, Wilder*	1.1.a) Using sources such as census data and government economic data, analyze demographic and economic trends to determine potential impact on climate variability.	**X**		
		1.1.b) Using a water balance model developed by CLIMAS, prepare an assessment of the sensitivity of water resources to climate vulnerability.	**X**	**X**	
		1.1.c) Conduct semi-structured interviews designed by the co-investigators to identify institutional changes, water management practices, and land use/tenure in Sonora, Mexico.	**X**		
	1.2) Assess the status of available climate information (both basins). ***Morehouse,*** *and Carter, Conde, Cavazos, Steiner*	1.2.a) Survey climate and meteorological agencies and other sources.	**X**		
	1.3) Assess stakeholder evaluation of climate information and determine stakeholder perception of product usability, accuracy, and utility for water management (both basins). ***Browning-Aiken, Merideth, Morehouse, Varady,*** *and Carter, Conde, Rodríguez , Romero, Sorrensen, Steiner, Wilder*	1.3.a) Using focus-group discussions based on questions developed via structured interviews and data-gathering, assess need for/use of climate information in the two basins.	**X**	**X**	
		1.3.b) Introduce stakeholders to climate forecasts and related information through periodic interactive educational workshops, as well as by means of follow-up surveys (based on CLIMAS and the Udall Center workshop experiences) to obtain feedback on utility, usability, and perceived accuracy of the information provided.		**X**	

	1.4) Identify potential opportunities to transfer climate information and forecasts into transboundary settings (San Pedro Basin) and regionally (Washita/Red-Arkansas Basin). ***Browning-Aiken, Merideth, Morehouse, Varady,*** *and Carter, Conde, Steiner*	1.4.a) Based on the results of surveys and focus groups, use structured workshop techniques to collaborate with basin residents in developing criteria for designing and implementing adaptive management strategies that reduce/avert vulnerability to climatic stresses.		**X**	
		1.4.b) Conduct qualitative/content analysis of results of focus groups, workshops, and surveys to assess climate perceptions and how these are linked with resource decisions/actions in both basins.			
2. Bridge communications gap	2.1) Identify areas where improvements in climate products could be made and provide feedback to climate scientists/forecasters, e.g. improved summer half-year precipitation forecasts (both basins). ***Browning-Aiken, Goodrich, Merideth, Morehouse, Varady,*** *and Carter, Cavazos, Conde, , Rodríguez, Romero, Sorrensen, Steiner, Wilder*	2.1.a) Conduct preliminary focus groups with watershed councils to ascertain how participants define and view climate, identify the types of climate conditions that pose the greatest concern to area residents, as well as the greatest potential benefit, and identify current coping mechanisms and strategies for identifying climate changes.	**X**	**X**	
		2.1.b) Based on the results of the focus groups, hold capacity-building workshops in the use and interpretation of climate information with watershed councils.	**X**	**X**	
	2.2) Improve climate experts' understanding of local climate variations (e.g. monsoon season forecasts) and clarify climate forecasting to make it more usable to local stakeholders (both basins). ***Browning-Aiken, Merideth, Morehouse,*** *and Carter, Cavazos, Conde, Romero, Sorrensen, Steiner, Wilder*	2.2.a) Design and undertake educational outreach for future capacity-building within watershed communities.		**X**	
	2.3) Narrow knowledge and communications gaps between climate researchers/products and area stakeholders (both basins). ***Browning-Aiken, Goodrich, Merideth, Morehouse, Varady,*** *and Carter,*	2.3.a) In Washita Basin, , facilitate interactions among local southwestern Oklahoma land and water agencies such as NRCS, local Oklahoma Water Resource Board offices, EPA, and tribes with the ARS-GRL and the University of Oklahoma's Mesonet.	**X**	**X**	

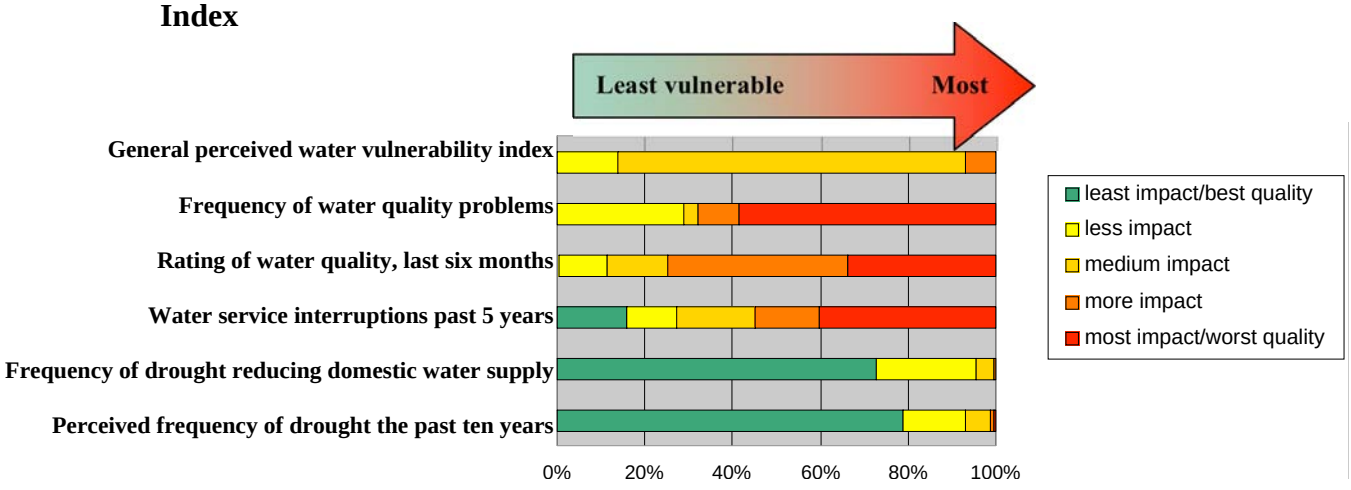
	Cavazos, Conde, Rodríguez, Romero, Sorrensen, Steiner, Wilder	2.3.b) In San Pedro Basin, facilitate interactions among U.S. and Mexican federal meteorological, water management, and natural resources agencies with respective state agencies and local groups (i.e., San Pedro Partnership, ARASA-Asociación Regional Ambiental de Sonora y Arizona)	**X**	**X**	

3. Integrate science and policy	3.1) Identify promising avenues for introducing science into policymaking (both basins) ***Browning-Aiken, Merideth, Morehouse, Varady,*** *and Carter, Sorrensen, Steiner, Wilder*	3.1.a) Evaluate the results of the research conducted in this project to determine extent to which science is already integrated into policy structures and the potential for/barriers to introduction of climate information into such processes.	**X**	**X**	
		3.1.b) Using information obtained from GIS, remote sensing technologies, surveys, policy analysis, and field interviews, organize climate and water discussions and information exchanges with watershed organizations.		**X**	**X**
		3.1.c) As part of ongoing water and climate forums, integrate science research with stakeholders' needs by inviting academic experts on climate and hydrology, such as Nicolas Piñeda of the University of Sonora (San Pedro Basin) and Oklahoma State University agricultural extension offices (Washita/Red-Arkansas Basin) to operationalize their data analysis and already available climate information to meet the needs of stakeholders.		**X**	**X**
		3.1.d) Identify changes that must be made in organizational, institutional, and professional frameworks in order to increase the integration of science into policy making and implementation processes, including enhanced participation of community members in scientific research as well as increased outreach from scientists to residents of the region.			**X**
	3.2) Assess the potential impacts of climate variability and change on water policy, economic development, and land management/land use practices (San Pedro Basin) ***Browning-Aiken, Merideth, Varady,*** *and Cavazos, Conde, Sorrensen, Wilder*	3.2.a) Using institutional analysis techniques (e.g., surveys and content analysis), analyze the Mexican institutional context in which domestic water users, municipal governments and agricultural producers make resource decisions, especially in light of the recent decentralization of water management from the federal to the local level.		**X**	**X**

		3.2.b) Using GIS and remote sensing technologies, identify changes in land productivity over time (time series) and correlate those changes to climate variations to determine regional climate vulnerability.		**X**	**X**
		3.2.c) Using techniques ranging from interviews to analysis of remote sensing imagery (see above), investigate land tenure, soil and water management in the Mexican portion of the San Pedro Basin for policy implications under conditions of climate variability and change.		**X**	**X**
	3.3) Identify innovative ways to link stakeholders with forecasters in regards to the ongoing work by the ARS-GRL in the Washita (Red-Arkansas) and ARS-SWRC in the San Pedro basins with forecast models for the interface between land use, climate and hydrology ***Browning-Aiken, Goodrich, Morehouse,*** *and Carter, Conde, Steiner*	3.3.a) Organize ongoing forums to utilize existing Udall Center/CLIMAS/ARS and NRCS communication networks within the two basins.	**X**	**X**	**X**
	3.4) Assess the potentials and constraints of using the watershed council framework and water focus groups for integrating science and policy (both basins). ***Browning-Aiken, Merideth, Morehouse, Varady,*** *and Cavazos, Conde*	3.4.a) Through semi-structured interviews and facilitated discussion groups, Identify the challenges in communication and collaboration between agencies, tribes, and other basin stakeholders and the changes that must be made in organizational, institutional, and professional frameworks in order to increase the successful integration of science and policy.			**X**

B. If appropriate, graphic(s) depicting any key research results thus far.

Graph 1: Distribution of Households along Perceived Water Vulnerability Index



C. Map of region covered by study (if applicable)
D. Photographs from fieldwork to depict study environment.
VI. Website address for further information (if applicable)
CLIMAS: http://www.ispe.arizona.edu/climas/
Upper San Pedro Partnership: http://www.usppartnership.com/
Udall Center for Studies in Public Policy: http://udallcenter.arizona.edu